Precommercial Thinning a Sapling-Sized Loblolly Pine Stand with Fire

Thomas A. Waldrop *and* **F. Thomas Lloyd,** *USDA Forest Service, Southeastern Forest Experiment Station, Department of Forestry, Clemson University, Clemson, SC 29634-1003.*

*ABSTRACT. A winter backing-fire in a natural 4-year-old loblolly pine (*Pinus taeda *L.) stand reduced stand density from 6,800 to 2,850 stems/ac, producing the effect of a thinning from below. Crown scorch was heavy, but needle consumption was infrequent. Mortality occurred when crown scorch exceeded 80% or needle consumption exceeded 20%. Much of the study area remained overstocked after burning and only a few areas within study plots were understocked. Diameter growth of surviving trees 1 year after burning was unaffected, but height growth was reduced by 33% compared to trees in unburned control plots. Growth of the first three flushes of terminal buds was reduced by prescribed burning, regardless of the degree of crown damage. Severe crown scorch caused an additional growth loss during the first flush. Additional research is required to develop guidelines for using fire for precommercial thinning.*

South. J. Appl. For. 12(3): 203-207.

Coastal Plain stands of loblolly pine (*Pinus taeda* L.) are often regenerated by natural means, whether by design or by accident. Since large seed crops are produced almost every year in this region (Langdon 1981), young stands are often too dense and may require precommercial thinning. Prescribed burning would be a low-cost method of precommercial thinning and was recommended by McNab (1977) for loblolly pine stands and Nickles et al. (1981) for shortleaf pine (*P. echinata* Mill.) stands. Although these studies included sapling-sized trees, their primary focus was on older loblolly pine and mixed pine-hardwood stands, respectively. This paper describes results after a prescribed winter backing-fire in a dense, 4-year-old natural loblolly pine stand.

METHODS

Study Area

The study was done on the Santee Experimental Forest in Berkeley County, SC, at an elevation of approximately 25 ft above mean sea level. Soils are Aeric Ochraquults of the Wahee series and are somewhat poorly drained and slowly permeable. Slopes range from 0 to 4%. Site index for loblolly pine at age 50 is 86 ft.

The study site was clearcut in November 1981 after a winter prescribed burn and three annual summer burns. Logging slash was piled by hand and burned the following March. The area was then planted with loblolly pine seedlings on an 8-by-12 ft spacing. After planting, the area was fertilized with 250 lb/ac of 0-46-0 triple superphosphate. Survival of planted seedlings was only 11% because of an infestation of pales weevil (*Hylobius pales* Hbst.). There

Reprinted from the *Southern Journal of Applied Forestry* Vol. 12, No. 3, August 1988

was no need to replant, however, because regeneration, from seed in place and from adjacent stands, was abundant.

The study was established in the winter of 1986, when the dominant trees, almost all loblolly pines, were 4 years old. Diameters at breast height ranged from less than 0.5 in. to 2.6 in. and averaged 0.6 in. Tree heights averaged 7.3 ft with a range of less than 5 ft to 15.6 ft. Stocking was approximately 6,800 stems/ac.

Study Design

The study design included split-plots in randomized complete blocks with five replications, two whole plots per replication, and two subplots per whole plot. Whole plots 131 feet square (0.4 ac) were assigned to blocks on the basis of having similar pretreatment stocking and size distributions. Each of the two whole plots within a replication was randomly selected to be burned or left as an unburned control. Whole plots were split into fertilized and unfertilized subplots (0.2 ac each) to observe the interaction of burning with fertilization, which was expected to accelerate the growth of dominant trees. Fertilized subplots received urea at 200 lbs elemental N/ac. An additional 25 lb elemental P/ac was applied as triple super phosphate to ensure a maximum growth response to N. Fertilizer was applied by hand soon after burning.

Burning Conditions

Prescribed burning was conducted on February 3, 1986, 4 days after a rain of 0.42 in. and 7 days after a rain of 0.91 in. Burning of study plots began at approximately 12:30 p.m. Ambient temperature was 70°F. and relative humidity was 38%. Winds were from the southwest at 3 to 5 mph. Fuels along the ground were light and moist, but the entire study area was covered with cured broomsedge (*Andropogon virginicus* L.), which carried the fires. As suggested by a preliminary study (Waldrop and Lloyd 1987), a backing fire was selected for this young stand. Flame heights were generally 1 to 3 ft, which is 6 to 26 btu/sec/ft using Byram's flame length index (Brown and Davis 1973). Occasionally, flame heights reached 4 to 5 ft (116 to 188 Btu/sec/ft) where vertical fuels (broomsedge and needle drape) were heavy. The rate of spread ranged from 2.5 to 3.6 ft/minute and the mean, over all replications, was 3.0 ft/minute. Burning was completed at approximately 1:30 p.m., having covered almost 100% of the study areas.

Measurements

Measurements taken in each burned plot included degree of crown damage, survival by dbh class, and stocking before and after burning. Growth of survivors was measured in both burned and unburned plots. Crown damage, expressed by degree of crown scorch and needle consumption, was estimated for every tree over 5 ft tall on a 0.04 ac sample plot in each of the 10 burned subplots. Sample plots were randomly located but with an adequate buffer between fertilized and unfertilized subplots. For each tree, the height to the bottom of the crown was measured prior to burning. In May 1986, 3 months after burning, the highest point of needle comsumption, highest node with scorched needles, total height, and dbh were measured. Scorched needles were those that were brown but completely intact. The highest point of needle consumption was generally evident where some parts of needles burned away leaving at least the fascicles intact. Crown scorch and needle consumption were expressed as percentages of the length of the crown. Each tree was tallied as alive or dead to compare dbh distributions before and after burning and to relate mortality to degree of crown damage.

Stocking levels before and after burning were estimated at 54 randomly located sample points throughout each burned plot. The nearest-neighbor technique (Clark and Evans 1954) was used by measuring the distance from each random point to the nearest tree (either alive or dead) and to the nearest live tree. Based on Pielou's Index of Nonrandomness (Pielou 1959), the distribution of trees in each burned plot was random before and after burning. Therefore, measured distances could be converted to point estimates of density by the method of Thompson (1956). Measurement of distance to the nearest tree and the nearest live tree alllowed a comparison of stocking before and after burning.

In each 0.04 ac sample plot, both in burned and unburned plots, the dbh and height of the largest 40 trees were measured at the beginning and end of the 1986 growing season. The largest 40 trees on each sample plot were designated as crop trees because they were the most likely to survive the burning treatment and reach rotation age. Each crop tree was tagged to follow the effect of crown damage on survival and growth over the first growing season after burning. Mean subplot dbh and height growth were compared by analysis of variance.

RESULTS AND DISCUSSION

Mortality and Size Distribution

Prescribed burning reduced the total number of stems/ac from 6,800 to 2,850 (58%) with the highest mortality rates in lower diameter classes (Figure 1). Mortality was 88% in the 0.2 in. class and 53% in the 0.6 in. class, but near 0 in larger dbh classes. This pattern of thinning was silviculturally desirable, resembling a thinning from below. Burning changed the diameter distribution from a reverse-J pattern, with large numbers of small trees, to a bell-shaped pattern with medium-sized trees being most frequent. As a result, mean tree dbh increased from 0.6 in. to 0.9 in. and mean tree height increased from 7.3 ft to 8.4 ft. These results closely resemble those of McNab (1977) in a much older (17.5

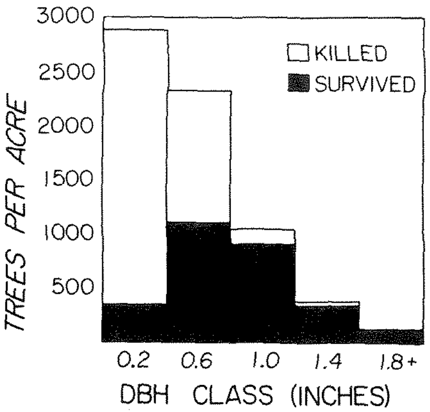


Figure 1. Change in dbh distribution of a natural 4-year-old loblolly pine stand after a winter backing-fire.

years) loblolly pine stand that had been burned.

Even though burning substantially reduced the total number of stems, the stand was still dense. A burn of somewhat higher intensity might have killed more small trees, producing a more satisfactory thinning. However, extreme caution is mandatory because small increases in fire intensity in young stands could cause large increases in mortality.

Crown Damage and Mortality

Crown damage from backing fires was heavy in all study plots. Over 5,500 trees/ac (81%) received at least 40% crown scorch, while over 4,200 trees/ac (62%) were totally scorched (Table 1). Even though crown scorch was heavy, the incidence of needle consumption was low (Table 2). Only 26% of all trees in sample plots showed evidence of needle consumption.

Needle consumption was most common on trees with severe crown scorch (Figure 2). Among those trees with less than 80% crown scorch, fewer than 15% showed any evidence of needle consumption. However, the occurrence of needle consumption increased sharply when crown scorch was over 80%, being observed on almost 40% of those trees with 100% crown scorch. These findings are similar to those of Wade (1985), who showed the frequency of needle consumption to be less than 10% among trees with less than 100% crown scorch.

Several studies have shown mortality of pole-sized or larger pines with severe crown scorch (Methven 1971, Villarrubia and Chambers 1978, and Waldrop and Van Lear 1984). However, studies by McNab (1977) and Johansen and Wade (1987) indicate that mortality of trees generally smaller than 1 in. dbh may be caused by stem or root damage. When working with trees of similar size to the crop trees of this study, Wade (1985) found mortality of over 50% among trees with 20% needle consumption or more. In the present study mortality was low among sampled crop trees with less than 80% crown scorch (Figure 3). Above 80% crown scorch, which is the same level at which needle consumption became frequent (Figure 2), mortality was very high. Over 90% of crop trees with 100% crown scorch died. Mortality was over 45% when needle consumption was only 20%, which is similar to the findings of Wade (1985).

Some mortality occurred at low levels of crown scorch (Figure 3), indicating that crown damage may not be the only cause of mortality. As suggested by McNab (1977) and Johansen and Wade (1986), some mortality was probably caused by stem or root damage. These data support the conclusion of Wade (1985) that mortality can be predicted by the degree of crown damage, but the actual cause of mortality may be damage to stems, roots, crowns, or any combination of the three.

Uniformity of Stocking

Before burning, the majority (80.1%) of the study area was overstocked (Table 3), where overstocked is defined as 1600 stems/ac or more. After burning, the majority of the area (54.3%) was stocked at levels of 400 to 1,200 stems/ac, which is acceptable for many forest products. The remaining 45.7% of the area was still overstocked, with as many as 12,000 stems/ac and an average of 2,850 stems/ac.

Even though additional thinning may be required in some areas of the stand, a single prescribed backing fire effectively lowered stocking levels over the entire study area. In addition, understocked areas (fewer than 400

Table 1. Trees/ac with various degrees of crown scorch after a winter backing-fire.

Percentage crown scorch	Trees/ac	Percentage of all trees
0	104	1.5
1–20	290	4.3
21–40	858	12.7
41–60	937	13.8
61–80	359	5.3
81–100	4228	62.4
Total	6776	100.0

Table 2. Trees/ac with various degrees of needle consumption after a winter backing-fire.

Percentage needle consumption	Trees/ac	Percentage of all trees
0	5016	74.0
1–20	283	4.2
21–40	273	4.0
41–60	336	5.0
61–80	417	6.2
81–100	451	6.6
Total	6776	100.0

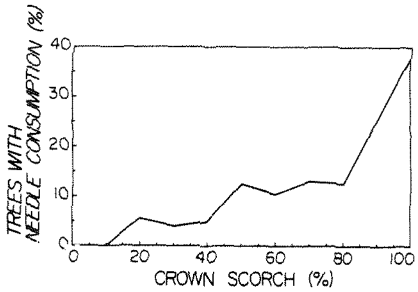


Figure 2. Frequency of trees with any degree of needle consumption at various levels of crown scorch.

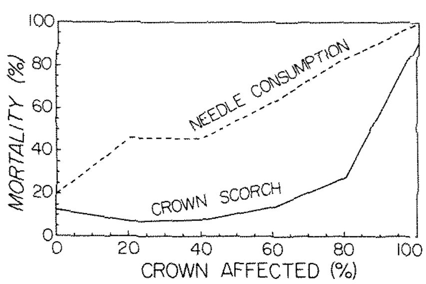


Figure 3. Mortality by percent crown scorch or needle consumption after a winter backing-fire.

Table 3. Percentage of the total study area stocked at various levels before and after burning.

Stocking level (stems/ac)	Before burning	After burning
	.... (%)	
400–799	3.4	27.9
800–1199	10.0	17.1
1200–1599	6.5	9.3
1600+	80.1	45.7
Total	100.0	100.0

stems/ac) were essentially absent. The absence of understocked areas indicates that uniform backing fires may be preferable to other techniques of prescribed burning where hot spots and, therefore, areas of high mortality are more frequent.

Tree Growth

When crown damage from burning is severe, pine growth is often reduced (McCulley 1950 and Johansen and Wade 1986). Even though crown scorch was severe throughout the study plots, damage to crop trees was relatively light. Among crop trees, degree of crown scorch ranged from 0 to 100% but the mean was only 56%. Only 25% of sampled crop trees had greater than 80% crown scorch. Analysis of variance showed no significant differences in mean diameter growth of crop trees in burned and unburned study plots (Table 4). Diameter growth was significantly increased by fertilization, but there was no interaction between burning and fertilization. In contrast, height growth of crop trees was significantly reduced by burning. In subplots that were not fertilized, height growth averaged 2.7 ft without burning as compared to only 1.8 ft in burned plots. In fertilized subplots, mean height growth for unburned controls and burned plots was 2.6 ft and 2.0 ft, respectively. As with diameter growth, height growth showed no interaction between burning and fertilization.

Since burning reduced height growth but not diameter growth, it was assumed that in highly scorched trees, carbohydrates stored in the roots and stem over winter were used for needle production and some diameter growth rather than for early stem elongation. Therefore, height growth may have been minimal during the first flush of buds, causing trees in burned plots to lag behind those in unburned controls.

To gain additional insight into the effect on height growth of burning, the number of flushes of the terminal shoot of each crop tree was counted in all burned and control plots. In addition, the length of each flush was measured. To examine impacts on growth, the number of flushes and the length of flushes were compared for crop trees in burned and unburned plots, for each of three crown scorch categories, by analysis of variance and linear contrast.

Prescribed burning had no significant effect on the number of growth flushes, regardless of degree of crown scorch (Table 5). Crop trees in control plots had a mean of 3.4 flushes the year after burning, while those in burned plots had 3.2 flushes. The length of the first flush during the growing season after burning was affected by degree of crown scorch, however. When crown scorch was light or moderate, the length of the first flush averaged 15 in., which was significantly less than the 17.3 in. for trees in unburned control plots. When crown scorch, and therefore defoliation, was heavy, the length of the first flush was further reduced to less than 12 in.

The second and third flushes of trees in burned plots were significantly shorter than those in unburned controls, but there were no significant differences among trees with light, moderate, or heavy crown scorch. Also, there were no significant differences in flush length between lightly scorched and moderately scorched trees for any of the four flushes measured. These data suggest that prescribed burning in young loblolly pine stands, regardless of the degree of crown damage, will reduce the growth of the first three flushes of the terminal leader and heavy crown scorch will cause an additional growth loss during the first flush.

The loss of height growth for trees with only light crown scorch, as compared to controls, was unexpected. This growth loss was apparent in all flushes of trees in burned plots and was statistically significant in the first three flushes. Since burning significantly reduced the length of the second and third flushes but the degree of crown scorch (light vs. moderate vs. heavy) had no apparent effect, it might be theorized that some form of physiological damage, in addition to crown scorch, was caused by burning. Although stem and root damage were not considered in this study, they may have contributed to the overall reduction in height growth.

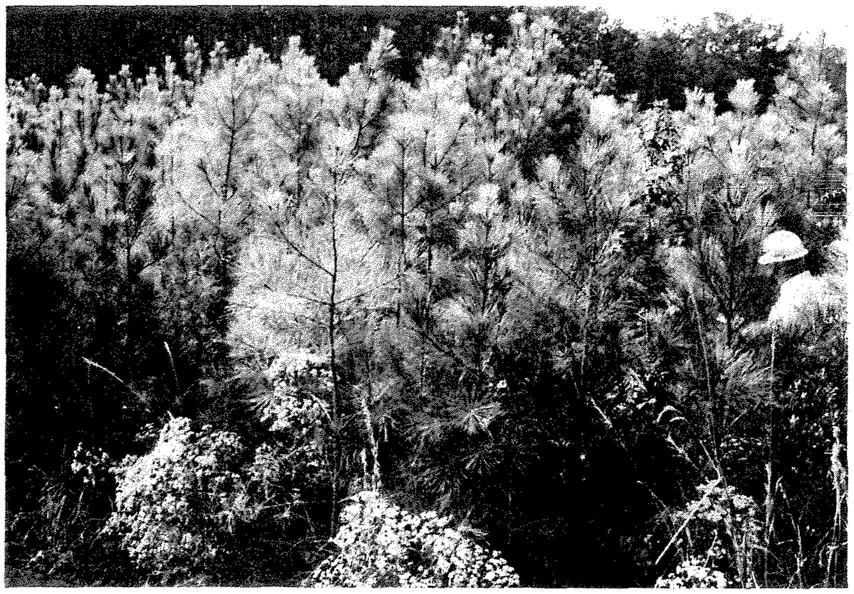
CONCLUSIONS

Prescribed burning effectively thinned a young loblolly pine stand at a cost much less than the cost of most methods of precommercial thinning. Since more than 2,800 stems/ac survived, however, the winter backing-fire did not achieve the goal of less than 1600 stems/ac. Even though a second precommercial thinning may be desirable, it may prove possible to postpone the next thinning until

Table 4. Diameter (dbh) and height growth one growing season after a winter backing- fire.

Treatment	dbh growth (in.)	Height growth (ft)
Burned—no fertilizer	0.31a[1]	1.8a
Unburned—no fertilizer	0.37a	2.7b
Burned—fertilized	0.47b	2.0a
Unburned—fertilized	0.48b	2.6b

[1] Means followed by the same letter within a column are not significantly different at the 5% level.



Natural regeneration of loblolly pine on the Coastal Plain can create over-stocked stands that require precommercial thinning. Broadcast direct seeding can result in similar conditions. Fire may prove a useful tool in thinning these stands at an early age.

Table 5. Number and length of flushes of the terminal shoot in crop trees with various degrees of crown scorch during the first growing season after a winter backing-fire.

Degree of crown scorch	n	Number of flushes	Length of flushes 1	2	3	4
			...... (in.)			
Control (no scorch)	381	3.4a[1]	17.3a	9.4a	6.4a	5.6a
Light (0–33% scorch)	76	3.2a	15.0b	6.2b	5.0b	4.0a
Moderate (34–67% scorch)	162	3.2a	14.9b	5.9b	5.0b	4.2a
Heavy (68–100% scorch)	24	3.2a	11.7c	4.7b	4.6b	4.5a

[1] Means followed by the same letter within a column are not significantly different at the 5% level.

trees reach merchantable size. If not, hand thinning may be conducted soon after burning at a cost that should be lower than it would be if the stand had not been burned.

With any fire, there is a risk of severe damage or death of crop trees. In this study, damage to crop trees was minimal and growth loss one year after burning was relatively small. However, in young stands small changes in fire intensity can produce substantially different results. For this method to be successful over a wide range of stand conditions, additional research is needed to develop guidelines and burning prescriptions. □

Literature Cited

Brown, A. A., and K. P. Davis. 1973. Forest fire control and use. McGraw-Hill, New York. 686 p.

Clark, P. J., and F. C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecol. 35:445–453.

Johansen, R. W., and D. D. Wade. 1986. Response of slash pine stands to severe crown scorch. P. 31–34 *in* Proc. fire manage.—the challenge of protection and use. Logan, UT.

———. 1987. An insight into thinning young pine stands with fire. P. 103–106 *in* Proc. fourth bienn. south. silvic. res. conf., Atlanta, GA.

Langdon, O. G. 1981. Natural regeneration of loblolly pine: A sound strategy for many landowners. South. J. Appl. For. 5:170–176.

McCulley, R. D. 1950. Management of natural slash pine stands in the flatwoods of south Georgia and north Florida. USDA Circ. 845. 57 p.

McNab, H. 1977. An overcrowded loblolly pine stand thinned with fire. South. J. Appl. For. 1:24–26.

Methven, J. R. 1971. Prescribed fire, crown scorch, and mortality: Field and laboratory studies on red and white pine. Can. For. Serv., Petawawa For. Exp. Stn. Inf. Rep. PS-X-31.

Nickles, J. K., C. G. Tauer, and J. F. Stritzke. 1981. Use of prescribed fire and hexazinone (Velpar) to thin understory shortleaf pine in an Oklahoma pine-hardwood stand. South. J. Appl. For. 5:124–127.

Pielou, E. C. 1959. The use of point-to-plant distances in the study of the pattern of plant populations. J. Ecol. 47:607–613.

Thompson, H. R. 1956. Distribution to the *n*th nearest neighbor in a population of randomly distributed individuals. Ecol. 37:391–394.

Villarrubia, C. R., and J. L. Chambers. 1978. Fire: Its effects on growth and survival of loblolly pine, *Pinus taeda*. Louisiana Acad. Sci. 41:85–93.

Wade, D. D. 1985. Survival in young loblolly pine plantations following wildfire. P. 52–57 *in* Proc. eighth nat. conf. on fire and forest meterology, Detroit, MI.

Waldrop, T. A., and F. T. Lloyd. 1987. Prescribed fire for precommercial thinning in a four-year-old loblolly pine stand. P. 97–102 *in* Proc. fourth bienn. south. silvic. res. conf., Atlanta, GA.

Waldrop, T. A., and D. H. Van Lear. 1984. Effect of crown scorch on survival and growth of young loblolly pine. South. J. Appl. For. 8:35–40.